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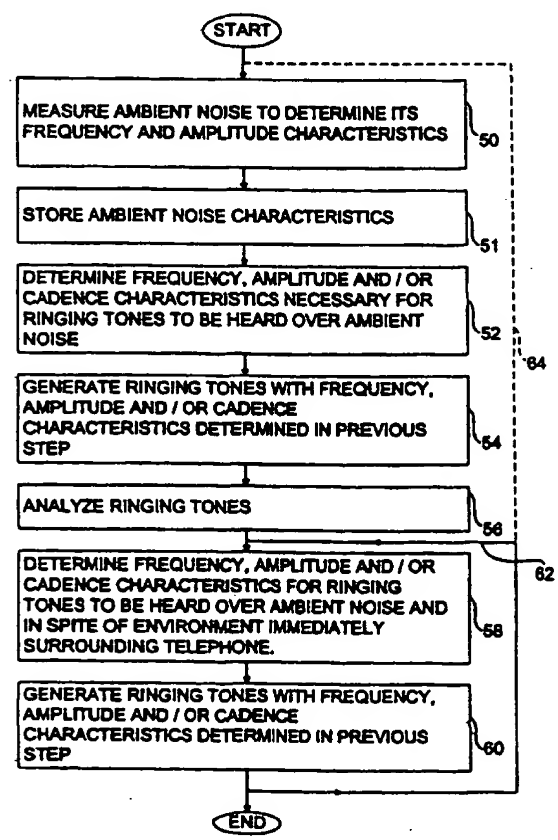
(54) Title: AUTOMATIC VOLUME CONTROL FOR A TELEPHONE RINGER

(57) Abstract

A telephone is provided with a means for automatically generating ringing tones to be heard by a user over ambient noise and in spite of any muffling environment in which the telephone may be located. The ambient noise is measured to determine its amplitude and frequency characteristics and appropriate amplitude and frequency characteristics of ringing tones to be heard by a user over the ambient noise are calculated and generated. The degree to which the ringing tones are muffled by the muffling environment is calculated and suitable amplitude and frequency characteristics of further ringing tones necessary to be heard by a user in spite of the muffling environment are calculated and further ringing tones having the suitable amplitude and frequency characteristics are generated.



AUTOMATIC VOLUME CONTROL FOR A TELEPHONE RINGER

Field of the Invention

The invention relates to portable telephones and is particularly concerned with a technique for automatically controlling the audible characteristics of ringing tones in portable telephones.

Background of the Invention

Unlike conventional telephones, portable telephones do not typically reside in a fixed location on a desktop, table or wall. Portable telephones often travel with their owners in cars, offices, parks, golf courses, etc. Accordingly, both the physical environment and acoustic environment surrounding the telephone change.

This environmental variability may prevent or hinder the user from hearing the ringing of the telephone. For example, if the user moves to a noisy environment, the ambient noise may interfere with the user being able to hear the ringing tones of the telephone. Similarly, if the user carries the telephone in a pocket, briefcase or purse, for example, the ringing tones may be muffled or reflected by the environment immediately surrounding the telephone, thereby also obscuring the sound of the ringer. In either scenario, the user may not be able to hear the ringing tones, thereby possibly missing a call.

Portable telephones typically provide a means for the user to manually adjust the volume (ie: amplitude) of the ringing tones. Such manual methods require the user to pre-select the desired volume of the ringing tone in anticipation of the required volume at the time that an incoming call subsequently arrives. However, if the user forgets (or simply neglects) to increase the volume of the ringing tones prior to entering a noisy location or prior to placing the telephone in a muffling environment (a briefcase or pocket, for example), the user may not then be able to hear the ringing tones. Alternatively, if the user has previously set the ringing tones to a loud volume and the user moves to a quiet environment, the

aresulting volume of the ringing tones may startle or disturb those in the local vicinity.

One known method of addressing the problem of increasing an alerting signal to a volume sufficient to be heard by a user has been implemented in some models of consumer alarm clocks and clock radios. Using this method, the initial volume of the alarm is set at a pre-determined level. If the user fails to intervene (eg: if the user fails to turn off the alarm), then after a pre-determined time interval, the volume of the alarm is increased by a pre-determined amount. In this manner, the volume of the alarm will continue to increase until it reaches some pre-determined maximum volume or the need for the alarm ceases. However, such a method would be of marginal effectiveness with respect to telephony, since an unanswered call will typically either be abandoned by the calling party or else answered by an answering machine or voice mail system prior to the time required for the volume of the alarm to reach the necessary level to be heard by the user.

The prior art also reveals, for example, European patent application No. 92302479.8 in the name of Nokia Mobile Phones Ltd., published on October 7, 1992, disclosing a telephone apparatus which senses the ambient noise level and adjusts the volume of the ringing tones accordingly. While such a device may operate effectively when the telephone is located in the same open space as the user, when the phone is located in a pocket, briefcase or purse, for example, the apparatus disclosed in the Nokia application would evaluate the ambient noise level without taking into account that the ringing tones generated by the telephone could be significantly muffled or obstructed by the environment immediately surrounding the telephone (pocket fabric, briefcase or purse). Indeed, if the Nokia device is located in an enclosed muffling environment (eg: a purse or briefcase), the amplitude of the ambient noise will be attenuated by the surrounding muffling materials. The Nokia device may therefore be "tricked" and fail to increase the volume of the ringing when such an adjustment is required. Further, while the device contemplated by the Nokia patent

considers the amplitude of the ambient noise, it fails to consider the frequency or temporal characteristics of the ambient noise.

The prior art does reveal a method which attempts to determine whether or not a telephone is located within a briefcase. For example, (the Derwent English language summary of) Japanese application 2058952 in the name of Matsushita Elec Ind KK, published on February 28, 1990, discloses a telephone device which increases the volume of the ringing tone when the device detects low lighting (apparently, low lighting suggests that the telephone is located within a briefcase). However, such a solution does not take into account the possibility that the telephone may be located in a dark room beside the user rather than in a briefcase. As well, this solution does not consider the different degrees to which the local environment may muffle the ringing tone. For example, the loudness of the ringing tone may have to be increased if the telephone is transferred from a thin fabric pocket to a more substantial briefcase.

Summary of the Invention

It is an object of the invention is to obviate or mitigate one or more of the above identified disadvantages.

According to a first broad aspect, the invention provides a telephone for generating ringing tones to be heard by a user over ambient noise comprising an ambient noise analysis means for determining at least one of the amplitude and frequency characteristics of the ambient noise; a calculation means for calculating appropriate audible characteristics of ringing tones to be heard by a user over the ambient noise wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones; and a ringing tone generating means for generating ringing tones with the appropriate audible characteristics.

According to a second broad aspect, the invention provides a telephone for generating ringing tones to be heard

by a user over ambient noise and in spite of an environment immediately surrounding the telephone, if any, comprising an ambient noise analysis means for determining at least one of the amplitude and frequency characteristics of the ambient noise; a calculation means for calculating appropriate audible characteristics of ringing tones to be heard by a user over the ambient noise, wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones; a ringing tone generating means for generating ringing tones with the appropriate audible characteristics; an environment analysis means for determining the effect on the ringing tones of the environment immediately surrounding the telephone, if any;
a further calculation means for calculating further appropriate audible characteristics of further ringing tones to be heard by a user in spite of the environment immediately surrounding the telephone, if any, wherein the further audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones; and a ringing tone generating means for generating the further ringing tones with the further appropriate audible characteristics.

According to a third broad aspect, the invention provides a telephone for generating ringing tones to be heard by a user in spite of an environment immediately surrounding the telephone, if any, comprising a probe signal generating means for generating an acoustic probe signal suitable for determining the effect on subsequently generated ringing tones of the environment immediately surrounding the telephone;
an environment analysis means for determining the effect on the probe signal of the environment immediately surrounding the telephone, if any; a ringing tone calculation means for calculating appropriate audible characteristics of ringing tones to be heard by a user in spite of the environment immediately surrounding the telephone wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tone; and

a ringing tone generating means for generating ringing tones with the appropriate audible characteristics.

In a preferred embodiment of the invention there is provided a telephone which automatically adjusts the audible characteristics (amplitude, frequency and/or cadence) of its ringing tones to overcome ambient noise and the effect of the environment immediately surrounding the telephone (which could be absorptive and/or reflective), thereby increasing the likelihood that the user will not miss calls and accordingly also increasing revenues for the telephone network provider as a result of fewer missed calls.

Brief Description of the Drawings

Preferred embodiments of the invention will now be described with reference to the attached drawings in which

Figure 1 is a simplified representation of a telephone emitting ringing tones in a muffling environment;

Figure 2 is a block diagram of part of a telephone circuit according to the preferred embodiment of the present invention;

Figure 3 is a flow chart depicting the process steps carried out by the preferred embodiment of the present invention;

Figure 4 is a functional block diagram of the DSP chip of Figure 2;

Figure 5 is a simplified representation of a telephone emitting ringing tones in a reflective environment; and

Figure 6 is a plot of representations of ringing tones 18 of Figure 2, at different times during the execution of the steps in the flow chart of Figure 3.

Detailed Description of the Preferred Embodiment

As described below, when considering the characteristics of ringing tones to be heard over ambient noise or in spite of a muffling environment, it is desirable to consider not only the amplitude of the ambient noise and the

ringing tones, but also to consider their constituent frequencies. For example, ambient noise of a given frequency and a given amplitude may be more occlusive than ambient noise of a different frequency and the same amplitude. This effect is known as masking. Accordingly, one method to help ensure that the ringing tones may be heard over ambient noise is to generate ringing tones of a frequency sufficiently different from that of the ambient noise to avoid masking of the ringing tones by the ambient noise. The optimal variation of amplitude or frequency of the ringing tones with respect to ambient noise of a given frequency and amplitude is determined empirically from field tests.

Another technique to help the user hear ringing tones over ambient noise or in spite of a muffling environment, which can be used separately or in combination with modification of the frequency or amplitude of the ringing tones, is to modify the cadence of the ringing tones. The cadence of the ringing tones is essentially the ringing pattern. Increased cadence is typically more noticeable to the user than less rapid cadence.

The preferred embodiment of the present invention relates to cellular telephones, and the following description will only refer to cellular telephones. However, with modifications obvious to one skilled in the art, typical non-cellular, cordless telephones and other portable devices can be modified to incorporate the elements of the invention.

As shown in Figure 1, which is a simplified diagram of a portable telephone in use, a telephone generally designated 10 includes a transducer 12 and a microphone 14. The telephone 10, as shown in Figure 1, is located within a muffling environment 16. A portion of the ringing tones 18 emitted from transducer 12 travel to microphone 14 with little attenuation, as represented by arrow 19. Some of the ringing tones 18 emitted from transducer 12 are attenuated by the muffling environment 16 prior to arriving at microphone 14 as indicated by arrow 20. This attenuation may affect some frequencies more than others, depending upon the nature of the muffling environment.

As shown in Figure 2, which is a block diagram of the preferred embodiment of the present invention, a trigger signal input 22 is connected between a microprocessor (not shown) and a signal processor 24. The output of the signal processor 24 is connected to a digital-to-analog converter 26 via a line 30. An output of the digital-to-analog converter 26 is connected to an amplifier 32. The amplifier 32 is connected to the transducer 12 which emits ringing tones 18. The microphone 14 which receives acoustic signals 34 is connected to a pre-amplifier 36 which in turn is connected to an analog-to-digital converter 38 which in turn is connected to the signal processor 24 via a line 39.

The signal processor 24 could incorporate one or more processing chips or, if the analog-to-digital converter 38 is not used, the signal processor 24 could incorporate a combination of analog circuitry and one or more processing chips. In the preferred embodiment, the signal processor is a digital signal processing ("DSP") chip 24.

The DSP chip 24, a type of microprocessor, is typically separate from the telephone's main microprocessor (not shown). As well as acting as a signal analyzer (which analyzes signals supplied by the microphone 14 through the pre-amplifier 36 and the analog-to-digital converter 38) the DSP chip 24 also runs the software which controls the processes described below. The telephone circuitry also includes other conventional components such as filters and the like (which are not shown in Figure 2) and together with the pre-amplifier 36 and the analog-to-digital converter 38 constitute signal processing circuitry.

The DSP chip 24 has stored therein one or more programs which carry out the process steps shown in the flow chart of Figure 3, some of which are represented by the blocks of the block diagram of Figure 4.

In use, when the DSP chip 24 receives a signal on input 22 from the microprocessor that there is an incoming call, the DSP chip 24 begins to analyze the characteristics of the incoming (ambient noise) signal from the microphone 14 as

indicated at block 50. Representations of the ambient noise characteristics are stored at block 51 for later consideration at blocks 52 and 58. Then, the DSP chip 24 determines audible characteristics of the ringing tones necessary to be heard over the ambient noise as indicated at block 52, and the DSP chip 24 generates a signal having appropriate audible characteristics through the digital-to-analog converter 26, the amplifier 32 and the transducer 12 as indicated at block 54.

The appropriate audible characteristics can be any combination of variations from a "default" amplitude, frequency or cadence of the ringing tones. For example, the appropriate audible characteristics may involve only an increase of the amplitude of the "default" ringing tones, or it may involve an increase in the amplitude and frequency, or an increase in the frequency and an decrease in the cadence or an increase in all three, etc.

The ringing tones, which are emitted from the transducer 12, are picked up by the microphone 14 and the resulting electrical signals exiting from the pre-amplifier 36 and the analog-to-digital converter 38 are analyzed by the DSP chip 24 as indicated at block 56. Analysis of the ringing tones in this manner provides data as to the degree to which the ringing tones have been attenuated (which may be substantial if the telephone is in a muffling environment such as in a purse or briefcase, for example). Appropriate characteristics of the ringing tones necessary to overcome both the ambient noise and the muffling caused by the environment immediately surrounding the telephone are then calculated by the DSP chip 24 as indicated at block 58. The DSP chip 24 then generates ringing tones having the appropriate audible characteristics through the digital-to-analog converter 26, the amplifier 32 and the transducer 12 as indicated at block 60. Subsequent testing of the ambient noise and muffling environment can be performed to determine more accurately the optimal audible characteristics of the ringing tones and to make appropriate adjustments until the user answers the telephone or until the caller hangs up. Each of these steps is described further below.

~~As described above with reference to block 50 of~~ figure 3, the DSP chip 24 analyzes the incoming ambient noise.To one skilled in the art, there are many ways to analyze an acoustic signal to determine its characteristics, including analog and digital techniques. In the preferred embodiment, the acoustic signal is analyzed by analysis algorithms performed by the DSP chip 24 to determine its amplitude and frequency characteristics. The DSP chip 24 then calculates an initial set of audible characteristics necessary for ringing tones to be heard by the user over the ambient noise (block 52 of Figure 3). This calculation can be accomplished using many different methods. One method is for the DSP chip 24 to consult a look-up table in the DSP chip's memory incorporating records relating to different possible ranges of amplitude and frequency characteristics of the ambient noise. For each record, there is a corresponding record incorporating information relating to the necessary change (over a default setting) of audible characteristics of the ringing tones to be heard over the ambient noise. The values in the corresponding record are determined empirically from field tests.

Of course, the appropriate audible characteristics of the ringing tones could also be determined by means of calculations determined by empirical testing. For example, if the ambient noise has frequency and amplitude characteristics X and Y, respectively, then the audible characteristics of the ringing tones may have to be varied relative to X and Y (according to a particular, empirically determined function) to overcome the ambient noise.

The DSP chip 24 then sends a signal on line 30 incorporating the appropriate audible characteristics to generate, through the digital-to-analog converter 26, the amplifier 32 and the transducer 12, ringing tones 18.

As described above with respect to block 56 of Figure 3, a test is then conducted to determine if the telephone 10 is in a muffling environment 16. One skilled in the art will know of various techniques for sensing the proximity of absorptive or muffling materials (which may interfere with the

transmission of ringing tones) including optical, infra-red or capacitive sensors. In the preferred embodiment, in order to determine if the telephone is in a muffling environment, the DSP chip 24 performs a spectral analysis on the portion of the ringing tones arriving at the microphone 34.

The acoustic properties of an initial set of ringing tones are preferably chosen to be rich in higher frequencies so as to be sensitive to sound attenuation caused by typical muffling environments such as clothing, purses, etc. The initial set of ringing tones may be conventional ringing tones generated by the telephone 10, designed to include higher frequencies. In other words, it is preferable to produce an initial set of ringing tones or a probe signal with particular frequency properties. For example, the probe signal, which could be "ringing tones", could also be a signal which may not sound like standard telephone tones. For example, the probe signal could be a broadband signal, such as white noise, which could include all frequencies, to allow a better determination of which frequencies are being attenuated by the environment immediately surrounding the telephone. The probe signal could be generated by a separate probe signal generator (not shown). However, in the preferred embodiment, the DSP chip 24 (in combination with the digital-to-analog converter 32, amplifier 32 and transducer 12) would be able to produce an appropriate probe signal and thus, a separate probe signal generator would not be necessary.

It should be noted that if the telephone 10 is located within a muffling environment 16, a portion of the ringing tones emitted from transducer 12 will be attenuated prior to reaching microphone 10. However, as shown in Figure 1, a portion of the ringing tones 18 from transducer 12 will travel to microphone 14 directly, independent of the environmental materials, as represented by arrow signal 19. As described below, in order to determine the amplitude and frequency characteristics of the attenuated signal, it is desirable to subtract the characteristics of the direct signal

represented by arrow 19 from the entire acoustic signal 34 reaching microphone 14.

All or part of the ringing tones 18 generated by the DSP chip 24 through the digital-to-analog converter 26, the amplifier 32 and the transducer 12, depending upon the degree to which the acoustic signal is muffled or attenuated by the muffling environment 16, will travel to the microphone 14.

Since the acoustic signal 34 comprises the sum of (a) the ambient noise, (b) the portion of the ringing tones that travelled directly from the transducer 12 to the microphone 14 and (c) the attenuated portion 20 of the ringing tones 18 that travelled from the transducer 12 to the microphone 14, the DSP chip 24 must determine the portion of the acoustic signal 34 constituting only the attenuated ringing tones by subtracting the signal characteristics of (a) and (b) from signal 34.

Figure 4, a functional block diagram of the DSP chip of Figure 2, shows some of the steps performed by the DSP chip 24. The output signal 30 from a ring generator 79 is applied to a compensation filter 72. The compensation filter 72 approximates the transmission characteristics of the direct acoustic path 19 (see Figure 1). At summing node 73, the output from compensation filter 72 is subtracted from the input signal 39, thereby effectively removing the contribution of the direct path signal 19 from the acoustic signal 34 received by the microphone 14.

At block 74, a frequency analysis is performed upon the output from summing node 73. Typically, the frequency analysis would be accomplished using a fast Fourier Transform algorithm, which is a signal processing technique familiar to those skilled in the art. At summing node 75, the ambient noise characteristics, which were stored at block 51 (Figures 3 and 4), are subtracted from the output of block 74, in order to compensate for the impact of any ambient noise.

The output from node 75, representing the signal characteristics of the attenuated ringing tones, is analyzed by the DSP chip 24 at block 76, which performs a high pass filter function. The process at block 76 selectively attenuates low-

frequencies and passes high frequencies (or the representations of these frequencies), since high frequencies are more subject to attenuation by external materials. Smaller amounts of high frequency energy are indicative of a greater attenuation of the ringing tones. Output from block 76 is passed to block 77 which performs a discriminator function to determine the characteristics of the attenuated signal 20 and thereby infer the nature of the muffling materials. Then, enhanced ringing tones can be produced which are suitable to be heard by a user in spite of the muffling environment. The appropriate audible characteristics of the ringing tones can be determined in many ways which would be obvious to one skilled in the art, including the methods described above with respect to determining appropriate characteristics of ringing tones to be heard over ambient noise, such as by the use of a look-up table or by means of calculations.

The output of block 77 is passed to a ring register 78 which stores the audible characteristics or parameters (frequently, amplitude, cadence) derived from discriminator 77 and used to drive ring generator 79. In the preferred embodiment, the ring register 78 is updated after each ringing burst with the newly-determined ringing characteristics (the output from discriminator 77). In this manner, the ringing tones or the ringing signal can be dynamically adjusted as the environment changes.

The output of block 78 is passed to block 79 which performs a ring generator function by generating through the digital-to-analog converter 26, the amplifier 32 and the transducer 12 ringing tones having the appropriate audible characteristics.

Some of the sequence of events may be further described by reference to Figure 6, which is a plot of the ringing tones 18 of Figure 2, shown at different times during the execution of the steps in the flow chart of Figure 3. An incoming telephone call arrives at time t0. From time t0 to time t1, the ambient noise is analyzed (block 50 of Figure 3) to determine initial ringing tone characteristics or

parameters, which are loaded into ring register 78. At time t1, a first burst of ringing tones 18 is generated (block 54 of Figure 3) and the ringing tones received by microphone 14 are analyzed (block 56 of Figure 3). New ringing tone parameters are calculated (block 58 of Figure 3) and loaded into ring register 78. A new burst of ringing tones 18 is generated at time t2 in accordance with the ringing tone parameters stored in ring register 78 (block 60 of Figure 3).

There are two general types of signal processing well-known to those skilled in the art, namely frequency-domain analysis and time-domain analysis. Both techniques can be used to infer an environment external to a telephone. In the preferred embodiment, frequency-domain analysis, as described above, is used to estimate the nature of muffling materials, if any, surrounding the telephone. However, where the telephone is located within a mostly reflective environment (as opposed to a mostly absorptive environment) time-domain analysis may be more useful. Figure 5 illustrates such a case where the ringing tones, instead of being absorbed by surrounding materials, are reflected by an enclosure.

To determine if the telephone 10 is in a predominantly reflective environment, as opposed to a predominantly absorptive environment, time-domain analysis can be used. For example, if a telephone is located in a typical fabric pocket, some of the ringing tones emitted by transducer 12 would be attenuated but relatively little would be reflected. However, if the telephone is located in a metal briefcase, for example, very little of the ringing tones would be attenuated, but a relatively large amount would likely be reflected by the surrounding surfaces. By using time-domain analysis, the extent to which ringing tones are reflected can be calculated (or estimated), and appropriate characteristics for further ringing tones can be calculated to be heard in spite of the reflecting environment.

As shown in Figure 5, which is a simplified representation of a telephone emitting ringing tones in a reflective environment, if a telephone 10 is located in a

reflecting environment 80, such as a metal-sided briefcase, for example, ringing tones may produce a number of acoustic reflections 82. Given that sound waves travel at approximately 1 foot per millisecond, and given the number of reflections 82 impinging upon microphone 14, it is possible, using well-known techniques, such as time-domain reflectometry, to determine the presence or absence of reflective surfaces nearby the telephone 10. For example, a relatively large number of reflections occurring within a short interval (typically 1-2 ms), is indicative of several reflective surfaces. It will be apparent that a combination of time-domain and frequency domain analysis can be used to produce a more accurate estimation of the materials surrounding the telephone than either analysis separately.

Repeated sensing of the ambient noise and the muffling environment will typically yield more accurate results than those produced during the initial sensing period. In the preferred embodiment, repeated analyses are performed to determine and accommodate variations in the telephone's environment. As shown by a line 62 in Figure 3, the steps represented at blocks 56 through 60 (analysis of muffling environment) can be repeated, as necessary. Alternatively, as shown by a broken line 64 in Figure 3, all the steps represented at blocks 50 through 60 (analysis of ambient noise and muffling environment) can instead by repeated, as necessary.

The usefulness of repeated analysis is shown in the following example. If the user hears the telephone ringing from within a pocket and then removes the telephone from the pocket, the loudness of the ringing tones should be reduced accordingly, which can be accomplished by repeated analysis of the muffling environment and modifying the ringing tones as appropriate.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practised otherwise than

as specifically described herein. Some examples of possible modifications are the following: the microphone 14 could be different from and located elsewhere than the main telephone mouthpiece and there could be two or more microphones apart from the main microphone; the transducer 12 could be different from and located elsewhere than the main telephone transducer and there could be two or more transducers apart from the main transducer; the functions described above with respect to the DSP chip 24 could conceivably be performed by filters and other circuitry; or the function of the DSP chip 24 could be performed within the telephone's main microprocessor or could be split between the DSP chip 24 and the main microprocessor. Although in the embodiment described above, both the ambient noise and the muffling environment are taken into consideration, either analysis could be considered alone in a telephone.

CLAIMS:

1. A telephone for generating ringing tones to be heard by a user over ambient noise comprising

(a) an ambient noise analysis means for determining at least one of the amplitude and frequency characteristics of the ambient noise;

(b) a calculation means for calculating appropriate audible characteristics of ringing tones to be heard by a user over the ambient noise wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones; and

(c) a ringing tone generating means for generating ringing tones with the appropriate audible characteristics.

2. The telephone of claim 1 wherein the ambient noise analysis means comprises a microphone, signal processing circuitry connected to an output of the microphone and a signal analyzer means connected to an output of the signal processing circuitry.

3. The telephone of claim 2 wherein the signal processing circuitry comprises a pre-amplifier and an analog to digital converter.

4. The telephone of any one of claims 2 and 3 wherein the signal analyzer means comprises a digital signal processing chip.

5. A telephone for generating ringing tones to be heard by a user over ambient noise and in spite of an environment immediately surrounding the telephone, if any, comprising

(a) an ambient noise analysis means for determining at least one of the amplitude and frequency characteristics of the ambient noise;

~~(b) a calculation means for calculating appropriate~~ audible characteristics of ringing tones to be heard by a user over the ambient noise, wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones;

(c) a ringing tone generating means for generating ringing tones with the appropriate audible characteristics;

(d) an environment analysis means for determining the effect on the ringing tones of the environment immediately surrounding the telephone, if any;

(d) a further calculation means for calculating further appropriate audible characteristics of further ringing tones to be heard by a user in spite of the environment immediately surrounding the telephone, if any, wherein the further audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tones; and

(e) a ringing tone generating means for generating the further ringing tones with the further appropriate audible characteristics.

6. The telephone of claim 5 wherein each of the ambient noise analysis means and the environment analysis means comprises a microphone, signal processing circuitry connected to an output of the microphone and a signal analyzer means connected to an output of the signal processing circuitry.

7. The telephone of claim 6 wherein the signal processing circuitry comprises a pre-amplifier and an analog to digital converter.

8. The telephone of any one of claims 6 and 7 wherein the signal analyzer means comprises a digital signal processing chip.

9. The telephone of claim 8 wherein the digital signal processing chip of the signal analyzer means of the environment analysis means performs a series of steps comprising

(a) subtracting the amplitude and frequency characteristics of the ambient noise from audible characteristics of a signal received by the microphone;

(b) approximating the transmission properties of the direct path unattenuated ringing tones;

(c) subtracting the result of step (b) from the result of step (a);

(d) performing a high pass filter function on the result of step (c); and

(e) performing a discriminator function on the result of step (d).

10. The telephone of any one of claims 5, 6, 7, 8 and 9 wherein the calculation means comprises a look-up table comprising records wherein each record relates to different possible ranges of the amplitude and frequency characteristics of the ambient noise and wherein for each record there is a corresponding record comprising representations of appropriate audible characteristics of ringing tones to be heard by a user over the ambient noise.

11. The telephone of any one of claims 5, 6, 7, 8, 9 and 10 wherein the environment analysis means determines at least one of the extent to which the ringing tones have been attenuated by the environment immediately surrounding the telephone and the extent to which the ringing tones have been reflected by the environment immediately surrounding the telephone.

12. The telephone of any one of claims 5, 6, 7, 8, 9, 10 and 11 wherein the environment analysis means performs at least one of a frequency-domain analysis and a time domain analysis.

~~13. A telephone for generating ringing tones to be heard by a~~ user in spite of an environment immediately surrounding the telephone, if any, comprising

(a) a probe signal generating means for generating an acoustic probe signal suitable for determining the effect on subsequently generated ringing tones of the environment immediately surrounding the telephone;

(b) an environment analysis means for determining the effect on the probe signal of the environment immediately surrounding the telephone, if any;

(c) a ringing tone calculation means for calculating appropriate audible characteristics of ringing tones to be heard by a user in spite of the environment immediately surrounding the telephone wherein the audible characteristics comprise at least one of the amplitude, frequency and cadence characteristics of the ringing tone; and

(d) a ringing tone generating means for generating ringing tones with the appropriate audible characteristics.

14. The telephone of claim 13 wherein the probe signal is a ringing tone.

15. The telephone of any one of claims 13 and 14 wherein the environment analysis means comprises a microphone, signal processing circuitry connected to an output of the microphone and a signal analyzer means connected to an output of the signal processing circuitry.

16. The telephone of claim 15 wherein the signal processing circuitry comprises a pre-amplifier and an analog to digital converter.

17. The telephone of any one of claims 15 and 16 wherein the signal analyzer means comprises a digital signal processing chip.

18. The telephone of claim 17 wherein the digital signal processing chip of the signal analyzer means of the environment analysis means performs a series of steps comprising

(a) approximating the signal properties of a probe signal that travelled directly to the microphone;

(b) subtracting the result of step (a) from the signal properties of the probe signal received by the microphone;

(c) performing a frequency analysis on the result of step (b); and

(d) performing a discriminator function on the result of step (c).

19. The telephone of any one of claims 13, 14, 15, 16, 17 and 18 wherein the environment analysis means determines at least one of the extent to which the probe signal has been attenuated by the environment immediately surrounding the telephone and the extent to which the probe signal has been reflected by the environment immediately surrounding the telephone.

20. The telephone of any one of claims 13, 14, 15, 16, 17, 18 and 19 wherein the environment analysis means performs at least one of a frequency-domain analysis and a time domain analysis.

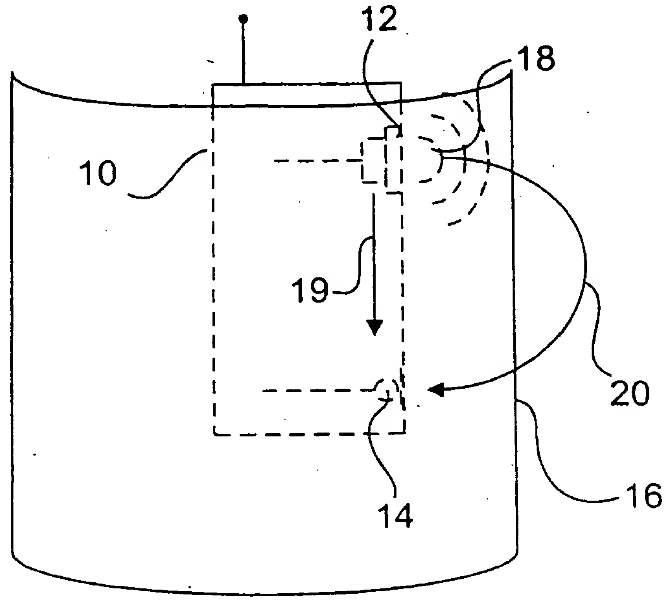


FIG. 1

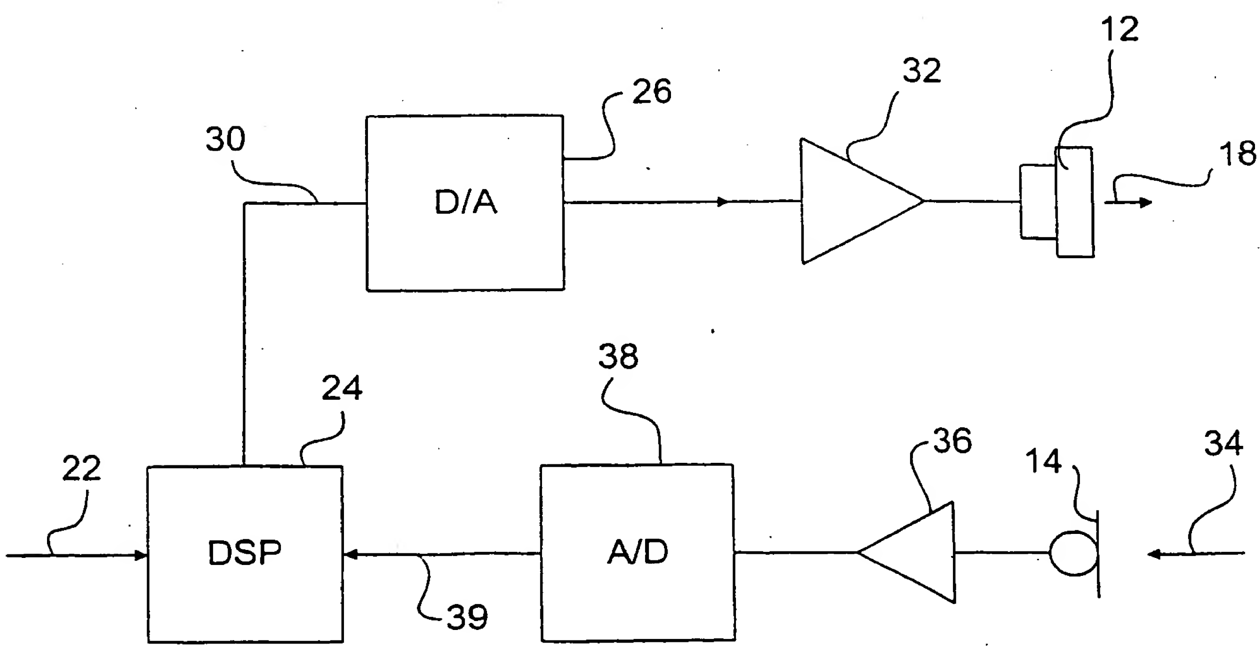


FIG. 2

FIG. 3

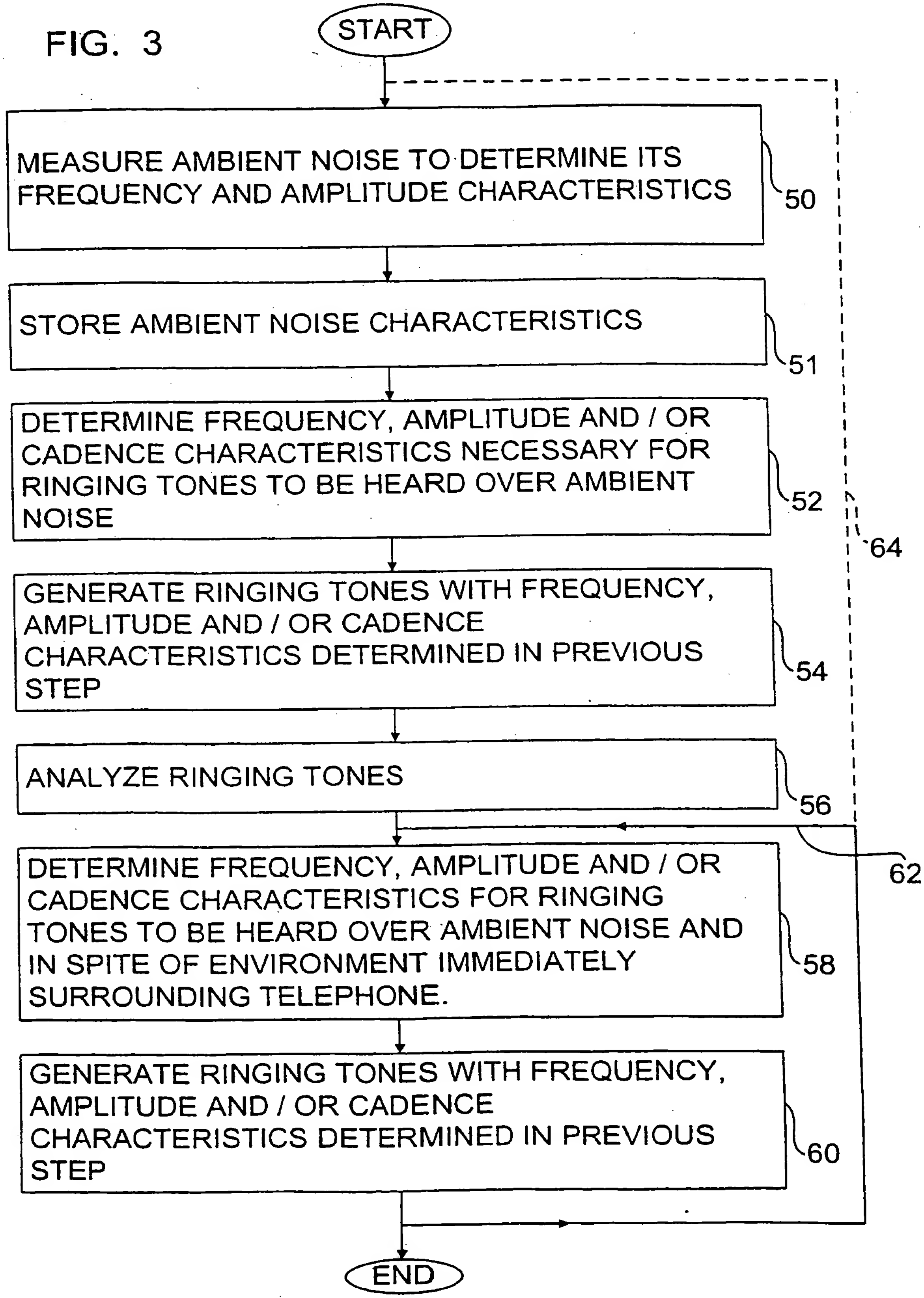
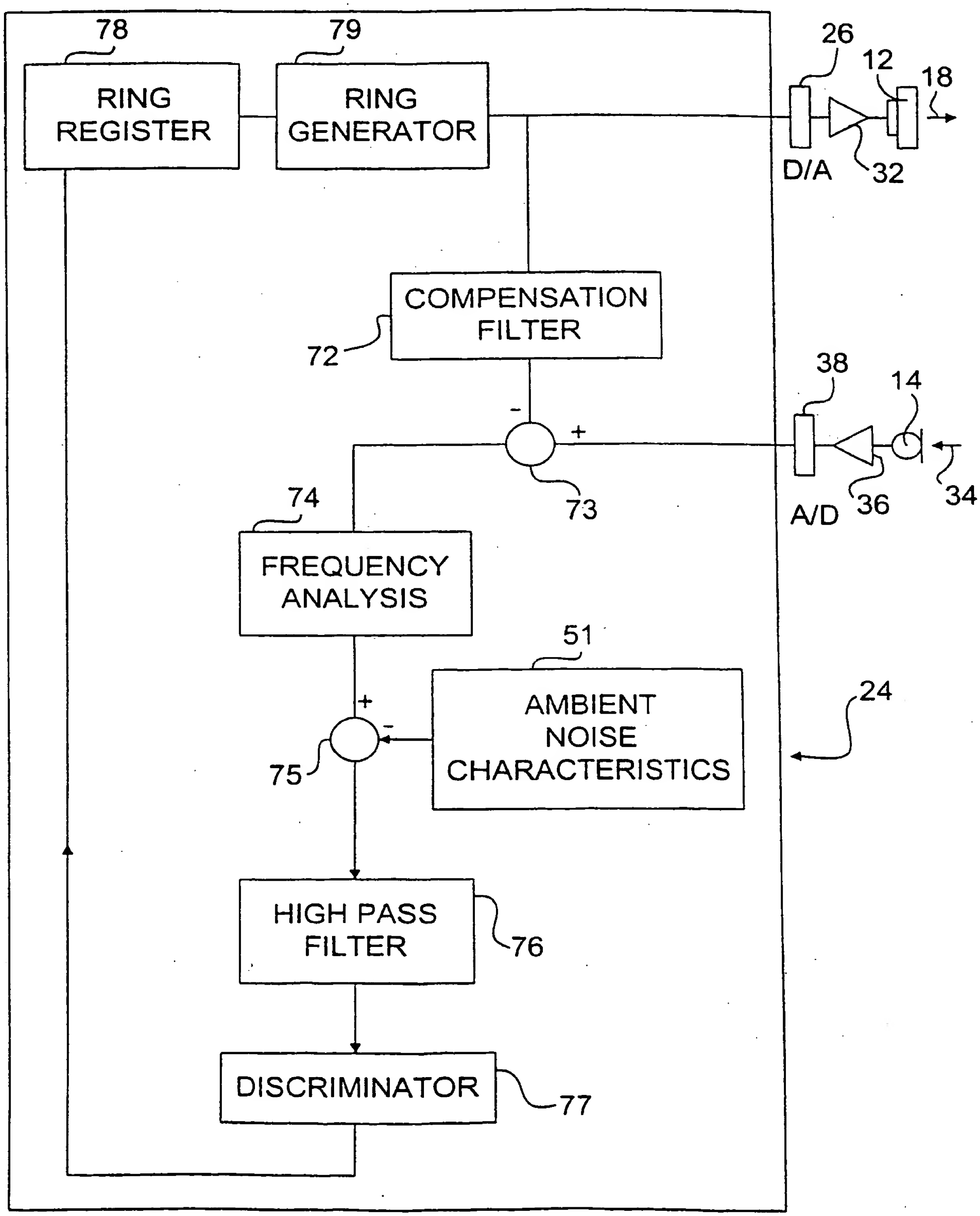

START
MEASURE AMBIENT NOISE TO DETERMINE ITS FREQUENCY AND AMPLITUDE CHARACTERISTICS
50
STORE AMBIENT NOISE CHARACTERISTICS
51
DETERMINE FREQUENCY, AMPLITUDE AND / OR CADENCE CHARACTERISTICS NECESSARY FOR RINGING TONES TO BE HEARD OVER AMBIENT NOISE
52
64
GENERATE RINGING TONES WITH FREQUENCY, AMPLITUDE AND / OR CADENCE CHARACTERISTICS DETERMINED IN PREVIOUS STEP
54
ANALYZE RINGING TONES
56
62
DETERMINE FREQUENCY, AMPLITUDE AND / OR CADENCE CHARACTERISTICS FOR RINGING TONES TO BE HEARD OVER AMBIENT NOISE AND IN SPITE OF ENVIRONMENT IMMEDIATELY SURROUNDING TELEPHONE.
58
GENERATE RINGING TONES WITH FREQUENCY, AMPLITUDE AND / OR CADENCE CHARACTERISTICS DETERMINED IN PREVIOUS STEP
60
END

FIG. 4


78
RING REGISTER
79
RING GENERATOR
26
12
18
D/A
32
COMPENSATION FILTER
72
38
14
-
+
73
A/D
36
34
74
FREQUENCY ANALYSIS
51
AMBIENT NOISE CHARACTERISTICS
24
+
-
75
HIGH PASS FILTER
76
DISCRIMINATOR
77

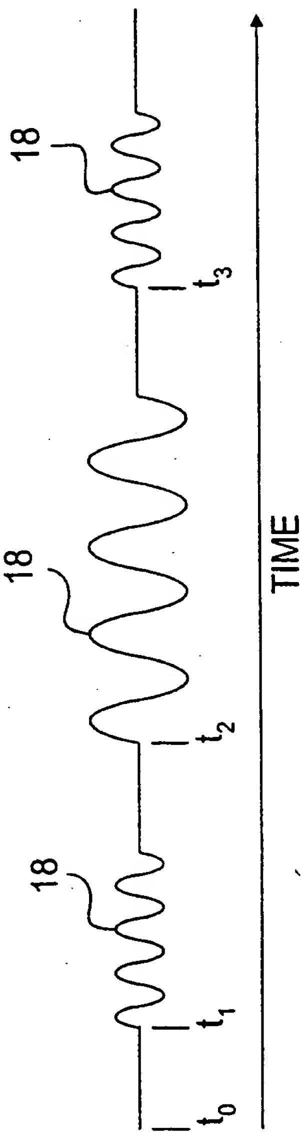


FIG. 6

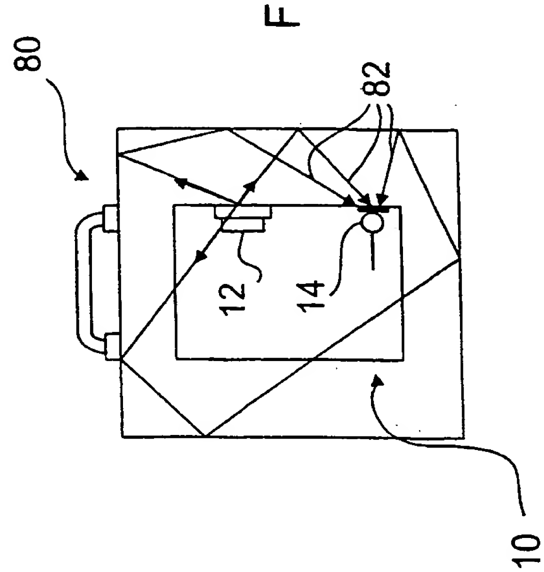


FIG. 5

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/CA 98/00676

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04M19/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04M H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 781 071 A (SAGEM) 25 June 1997 see page 3, column 4, line 6 - column 5, line 47	1-20
A	EP 0 507 482 A (NOKIA MOBILE PHONES LTD) 7 October 1992 cited in the application see the whole document	1-20
A	US 4 076 968 A (WATTENBARGER BLAKE LANE) 28 February 1978 see abstract	1-20
A	US 5 617 472 A (YOSHIDA TOSHIO ET AL) 1 April 1997 see the whole document	1-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 November 1998	04/12/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Montalbano, F

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 98/00676

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0781071 A	25-06-1997	FR 2742953 A	27-06-1997
EP 0507482 A	07-10-1992	FI 87872 B JP 5091166 A	13-11-1992 09-04-1993
US 4076968 A	28-02-1978	NONE	
US 5617472 A	01-04-1997	GB 2285376 A,B JP 2586847 B JP 7235969 A	05-07-1995 05-03-1997 05-09-1995

ORIGINAL
NO MARGINALIA